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This publication is designed to educate high school students about the problems and challenges of transportation. The parent project was conceived as a mathematics curriculum project but developed into an interdisciplinary project to ensure that students would become well informed regarding the transportation decisions they make. In the activities in this booklet, students learn methods for solving problems that involve different units of measurement. These techniques for relating units are often called dimensional analysis. Students use what they learn to compute some of the costs associated with driving to evaluate some of the advantages of other modes of transportation. Cost analysis exercises compare costs of running and maintaining an automobile with the cost of taking mass transit. (PVD)

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TRANSPORTATION DEMAND MANAGEMENT

Transportation Choices

STUDENT'S EDITION

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TRANSPORTATION DEMAND MANAGEMENT

Transportation Choices

STUDENT'S EDITION

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Preface

The Transportation Demand Management documents began to take shape in 1993, when the California Department of Transportation (Caltrans) and the California Department of Education undertook a joint project to educate the students of California about the problems and challenges of transportation. The project was conceived as a mathematics curriculum project and then developed into an interdisciplinary attempt to ensure that students would become well informed regarding the transportation decisions they make, now and in the future.

The Department of Education recruited a team of university and high school mathematicians, Caltrans personnel, and professionals from the business community to develop the four mathematics units for high school students: *Transportation Choices, Data Analysis, Downtown Distances,* and *Choosing a Delivery Route.*

Working from the mathematics units, educators in history–social science, English–language arts, environmental education, and industrial technology took on the task of making meaningful connections between their disciplines and the transportation issues discussed in the mathematics documents. The two documents they produced are *Problems, Issues, and Public Policy Choices: A History–Social Science Resource Unit* and *Investigations and Problem Analysis: A Science Resource Unit, Grades Eight Through Twelve.*

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Transportation Choices

Student's Edition

How many feet do you travel in a second when you are driving at a speed of 55 miles per hour? Which is a better deal—2 liters of soda for $1.29 or six 12-ounce cans for $1.49? If your car gets 25 miles per gallon of gas, you drive at 50 miles per hour, and you have 12 gallons in your car, how long will it take until you run out of gas? In this section you will learn a method for solving these and many other problems that involve different units of measurement. Then you'll use what you've learned to compute some of the costs associated with driving to evaluate some of the advantages of other modes of tranportation.

In this unit, you will find frequent questions. It is important that you stop reading and answer each question before you continue reading. Your teacher will tell you what form those answers should take—written or oral.

Units of Measurement

Most situations in which we use mathematics involve measurement, which is usually expressed in terms of **units**, such as gallons, miles, seconds, ounces, teaspoons, or dollars. For most things, several different types of measurement can be made. For example, to measure time, we can use seconds, minutes, hours, days, months, years, decades, centuries, or millennia. And for measuring the volume of a liquid, we can use teaspoons, tablespoons, cups, pints, quarts, gallons, liters, cubic feet, or acre feet.

1. Units of Measurement

With your group, list as many units of measurement as you can.

Exercises

1. From items around your house, find three more units of measurement that weren't discovered in class.

2. Place these units of measurement into the appropriate clusters you compiled in class (or you might need a new cluster).

3. Find an equivalence that wasn't found in class between two of the units of measurement you listed in class today. You might want to consult a reference book, such as a cookbook, dictionary, encyclopedia, or science book.

While unit conversions between some units within a cluster are familiar, some are not so familiar. No one is likely to remember how many inches there are in a mile or how many acres there are in a square mile, but we can find these from some other more common unit conversions.

2. Seconds in a Year

How many seconds are there in a year?

There is another way to find these conversions that is easier to use in most cases. When you divide a quantity by something that is equal to that quantity, you get the number 1. For example, since $7 \times 3 = 21$, we have $\frac{7 \times 3}{21} = 1$. Think of the equation 24 hours = 1 day as telling us that two quantities, 24 hours and 1 day, are equal. This means that $\frac{24 \text{ hours}}{1 \text{ day}} = 1$.

Similarly, $\frac{12 \text{ inches}}{1 \text{ foot}} = 1$, $\frac{60 \text{ minutes}}{1 \text{ hour}} = 1$, $\frac{31,536,000 \text{ seconds}}{1 \text{ year}} = 1$.

While this might seem like a peculiar way of writing things, it can help us to convert units when we use the rules for multiplying and simplifying fractions.

3. Unit Conversions to Fractions

Express the unit conversions that you found before as fractions that are equal to 1.

We also commonly refer to there being 24 hours per day, or writing 24 hours/day, which is just another way of writing $\frac{24 \text{ hours}}{1 \text{ day}} = 24 \frac{\text{hours}}{\text{day}}$. It is common to leave off the "= 1." So we also might see $12 \frac{\text{inches}}{\text{foot}}$ or $60 \frac{\text{minutes}}{\text{hour}}$ or $31,536,000 \frac{\text{seconds}}{\text{year}}$.

We can reduce a fraction when the numerator (the top) and the denominator (the bottom) have a factor in common by eliminating that factor. For example, $\frac{6}{15} = \frac{2 \times 3}{5 \times 3}$. Now, since

$$\frac{2 \times 3}{5 \times 3} = \frac{2}{5} \times \frac{3}{3} = \frac{2}{5} \times 1 = \frac{2}{5},$$

we see that we have effectively eliminated the 3 from the numerator and denominator because it was a factor of both.

We can do the same thing with fractions whose components are numbers and units. For example, if we multiply the fraction $\frac{60 \text{ seconds}}{1 \text{ minute}}$, which we know is just the number 1, by the fraction $\frac{60 \text{ minutes}}{1 \text{ hour}}$, which we also know is just the number 1, we'll get

$$\frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = 1 \times 1 = 1.$$

Since we multiply fractions by multiplying on the top and bottom, we have

$$\frac{60 \text{ seconds} \times 60 \text{ minutes}}{1 \text{ minute} \times 1 \text{ hour}} = 1.$$

Now notice that the same factor—minutes—occurs on the top and bottom, so we can eliminate it to get:

$$\frac{60 \text{ seconds} \times 60 \text{ minutes}}{1 \text{ minute} \times 1 \text{ hour}} = \frac{60 \text{ seconds} \times 60}{1 \times 1 \text{ hour}} = 1.$$

or

$$\frac{3,600 \text{ seconds}}{1 \text{ hour}} = 1,$$

which means that 3,600 seconds = 1 hour.

Let's use this same technique to find out how many centimeters there are in a yard, starting with the fact that there are 2.54 centimeters (cm) in an inch. We have

$$2.54 \text{ cm} = 1 \text{ inch or } \frac{2.54 \text{ cm}}{1 \text{ inch}} = 1.$$

Now because there are 36 inches in a yard, multiply by $\frac{36 \text{ inches}}{1 \text{ yard}} = 1$ to get

$$\frac{2.54 \text{ cm}}{1 \text{ inch}} \times \frac{36 \text{ inches}}{1 \text{ yard}} = \frac{2.54 \text{ cm} \times 36 \text{ inches}}{1 \text{ inch} \times 1 \text{ yard}} = 1.$$

We can eliminate the units of inches from the numerator and denominator to get

$$\frac{2.54 \text{ cm} \times 36 \text{ inches}}{1 \text{ inch} \times 1 \text{ yard}} = \frac{2.54 \text{ cm} \times 36}{1 \text{ yard}} = \frac{91.44 \text{ cm}}{1 \text{ yard}} = 1,$$

which means that there are 91.44 centimeters to a yard.

Here's another example of the versatility of this method—finding how many inches there are in a meter. There are 2.54 centimeters in an inch, which means 2.54 cm = 1 inch. We can divide this by 1 inch to get $\frac{2.54 \text{ cm}}{1 \text{ inch}} = 1$ or we can divide by 2.54 cm to get $\frac{1 \text{ inch}}{2.54 \text{ cm}} = 1.$

Both are true, but watch the steps that follow to see why $\frac{1 \text{ inch}}{2.54 \text{ cm}} = 1$ is more useful in this case. Since there are 100 centimeters in a meter, we have $\frac{100 \text{ cm}}{1 \text{ meter}} = 1$. We can now multiply the fractions

$$\frac{1 \text{ inch}}{2.54 \text{ cm}} \times \frac{100 \text{ cm}}{1 \text{ meter}} = 1$$

and eliminate the centimeters from the numerator and denominator to get:

$$\frac{1 \text{ inch} \times 100 \text{ centimeters}}{2.54 \text{ centimeters} \times 1 \text{ meter}} = \frac{1 \text{ inch} \times 100}{2.54 \text{ meters}} = 1 \text{ or } \frac{100 \text{ inches}}{2.54 \text{ meters}} = 1.$$

This is the same as

$$1 = \frac{100 \text{ inches}}{2.54 \text{ meters}} = \frac{100}{2.54} \frac{\text{inches}}{\text{meter}} = 39.37 \frac{\text{inches}}{\text{meter}} = \frac{39.37 \text{ inches}}{1 \text{ meter}}$$

which means that there are 39.37 inches in a meter.

A unit conversion can take many steps, requiring several steps of multiplication of fractions that are equal to 1. For example, to find out how many grams there are in a ton, we can use the fact that there is approximately .03527 ounce in a gram, 16 ounces in a pound, and 2,000 pounds in a ton. We want to know how many grams per ton, so we want to start with a fraction that has grams in the numerator. Since .03527 ounce = 1 gram, we can divide by .03527 ounce to get $\frac{1 \text{ gram}}{.03527 \text{ ounce}} = 1$. Now, to eliminate the ounces in the denominator (bottom) of this, multiply by some fraction (that is equal to one) with ounces in its numerator (top). This suggests that we multiply by $\frac{16 \text{ ounces}}{1 \text{ pound}} = 1$ to get

$$\frac{1 \text{ gram}}{.03527 \text{ ounce}} \times \frac{16 \text{ ounces}}{1 \text{ pound}} = \frac{16 \text{ grams}}{.03527 \text{ pound}} = 1.$$

Now we have pounds in the denominator. If we multiply this by some fraction (that is equal to 1) with pounds in the numerator, we can eliminate pounds, so we multiply by $\frac{2{,}000 \text{ pounds}}{1 \text{ ton}} = 1$, and get

$$\frac{16 \text{ grams}}{.03527 \text{ pound}} \times \frac{2{,}000 \text{ pounds}}{1 \text{ ton}} = \frac{32{,}000 \text{ grams}}{.03527 \text{ ton}} = \frac{32{,}000}{.03527} \frac{\text{grams}}{\text{ton}} = 907{,}286 \frac{\text{grams}}{\text{ton}} = 1$$

which means that there are approximately 907,286 grams in a ton. Many people prefer to do this in fewer steps:

$$\frac{1 \text{ gram}}{.03527 \text{ ounce}} \times \frac{16 \text{ ounces}}{1 \text{ pound}} \times \frac{2{,}000 \text{ pounds}}{1 \text{ ton}} = \frac{32{,}000 \text{ grams}}{.03527 \text{ ton}} = \frac{907{,}286 \text{ grams}}{1 \text{ ton}} = 1.$$

4. Teaspoons in a Cup

Use these techniques to find out how many teaspoons there are in a cup, given that there are 3 teaspoons in a tablespoon and 16 tablespoons in a cup.

5. Liters in a Gallon

Use these techniques to find out how many liters there are in a gallon, given that there are approximately 33.814 ounces in a liter, 32 ounces in a quart, and 4 quarts in a gallon.

6. Write an Exercise

Write an exercise for unit conversion, such as teaspoons in a cup or liters in a gallon. Be sure that you supply all of the information that is needed to find the conversion. Write a solution to your exercise.

We've used this technique to relate units that measure distance, time, and volume. We can also use this technique to relate units of different types, such as units of weight (ounces) and monetary units (dollars). When you purchase a large can of tomatoes, and pay \$1.19 for 28 ounces of tomatoes, you have established the relationship 1.19 dollars = 28 ounces. This could become the fraction $\frac{1.19 \text{ dollars}}{28 \text{ ounces}} = 1$ or $\frac{1.19 \text{ dollars}}{28 \text{ ounces}} = \frac{.0425 \text{ dollar}}{1 \text{ ounce}} = 1$. This means

that you are paying .0425 dollar, or 4.25 cents, per ounce of tomatoes. When you purchase a smaller can of tomatoes, and pay $.69 for 14.5 ounces of tomatoes, you have .69 dollar = 14.5 ounces, or $1 = \frac{.69 \text{ dollar}}{14.5 \text{ ounces}} = \frac{.047586 \text{ dollar}}{1 \text{ ounce}}$. So when you purchase this smaller can of tomatoes, you are paying .047586 dollar, or 4.7586 cents, per ounce of tomatoes. You pay a little bit more for each ounce of tomatoes when you purchase the smaller can. The next time you are in a grocery store, look at the small print on the price tags that are on the shelves, especially for the canned goods. You'll probably find the **unit price,** which is usually the price per ounce, of the product. For example, on the shelf tag for the 28-ounce can of tomatoes selling for $1.19, you would find the number .0425. This conversion allows the consumer to compare the prices of items of different sizes. Unit pricing is just one application of the relationships between units.

7. Unit Prices

Find the unit prices (in dollars per ounce) to decide which is the best deal: a 36-ounce package of spaghetti that costs $2.49, a 16-ounce package of spaghetti that costs $1.09, or a 12-ounce package of spaghetti that costs $.89.

We can also use our techniques to relate units such as volume and weight. For example, 1 cubic foot of water (the amount of water that would fill a bucket shaped like a cube with each side 1 foot long) weighs 62.5 pounds. Think of this as meaning that for water, 1 cubic foot = 62.5 pounds, which we could also write as $\frac{62.5 \text{ pounds}}{1 \text{ cubic foot}} = 1$.

This equation enables us to relate a weight of water to a volume of water. For example, if we want to know how many quarts of water there are in a cubic foot of water, we can use the fact that for water, 1 pint = 1 pound. There is even an old verse to remember this, "A pint's a pound the world around." First think about what it is that we are trying to find. In this case we want to know about quarts per cubic foot. So we want something with quarts in the numerator (top). We can relate quarts to pints, because there are 2 pints to a quart. So we start with $\frac{1 \text{ quart}}{2 \text{ pints}} = 1$. To get the pints out of the denominator, multiply by a fraction that is equal to 1 that has pints in the numerator, $\frac{1 \text{ pint}}{1 \text{ pound}} = 1$. This will leave us with pounds in the

denominator, so we next multiply by a fraction that is equal to 1 that has pounds in the numerator, $\frac{62.5 \text{ pounds}}{1 \text{ cubic foot}} = 1$. Now we have

$$1 = \frac{1 \text{ quart}}{2 \text{ pints}} \times \frac{1 \text{ pint}}{1 \text{ pound}} \times \frac{62.5 \text{ pounds}}{1 \text{ cubic foot}} = \frac{62.5 \text{ quarts}}{2 \text{ cubic feet}} = \frac{31.25 \text{ quarts}}{1 \text{ cubic foot}}.$$

There are 31.25 quarts in a cubic foot.

This technique for converting or relating units also enables us to solve other kinds of problems. For example, if a car is traveling at a speed of 55 miles per hour, this relationship is like a unit conversion. You can keep track of how far the car has traveled by knowing how much time has passed, or you can keep track of how much time has passed by knowing how far the car has traveled. Every hour of time spent driving will equal 55 miles of travel—1 hour = 55 miles. Thus we get $\frac{55 \text{ miles}}{1 \text{ hour}} = 1$. This is true only for a vehicle traveling 55 miles per hour—without that context it wouldn't make much sense to say that 1 hour = 55 miles.

Let's find out how many feet per second this car is traveling. We need to convert from miles to feet and from hours to seconds. We can use the facts that 1 mile = 5,280 feet, 1 hour = 60 minutes, and 1 minute = 60 seconds. Since our answer should be in feet per second, we start with a fraction that is equal to 1 that has feet in the numerator. We multiply this by fractions that are equal to 1 that will allow us to get a fraction with seconds in the denominator:

$$\frac{5,280 \text{ feet}}{1 \text{ mile}} \times \frac{55 \text{ miles}}{1 \text{ hour}} \times \frac{1 \text{ hour}}{60 \text{ minutes}} \times \frac{1 \text{ minute}}{60 \text{ seconds}} = 1.$$

Now eliminate miles, hours, and minutes and perform the arithmetic on the numbers in the numerator and denominator:

$$\frac{5,280 \text{ feet} \times 55}{60 \times 60 \text{ seconds}} = \frac{290,400 \text{ feet}}{3,600 \text{ seconds}} = \frac{80.67 \text{ feet}}{1 \text{ second}} = 1.$$

So the car that is moving at 55 miles per hour is traveling at 80.67 feet per second—every second this car travels 80.67 feet!

8. Gallons and Dollars Per Hour

On the freeway, a car travels at 55 miles per hour and gets 28 miles per gallon of gas. How many gallons per hour is the car using? If the gasoline costs $1.10 per gallon, how many dollars per hour is the car driver spending on gasoline?

9. Brush Fire

A brush fire destroyed 50 acres in 45 minutes. There are 640 acres in a square mile. If the fire had continued at this same rate, how many square miles would the fire have consumed in a day?

10. Track Records

Find your school records for several running events for your track and field team. Find out how many miles per hour the runner was traveling on average during these events.

Exercises

4. In 1994, the winning times in the Boston Marathon were

Men's Run:	2:07.15
Women's Run:	2:21.45
Men's Wheelchair:	1:21.23
Women's Wheelchair:	1:34.22

   A marathon is 26 miles and 385 yards long. Use this information to find the average speed in miles per hour over the marathon route for each of these four competitors.

5. Write an exercise that calls for the conversion of a velocity to miles per hour, such as the last problem. Also include your solution to the exercise.

These techniques for relating units are often called **dimensional analysis.** Dimensional analysis is used in many very different professions, by people who consider it to be one of the important tricks of their trade. Anyone who works with quantities that are measured—accountants, engineers, cooks, architects, building contractors, designers, and so forth—is apt to need to relate units and to find dimensional analysis useful. It is particularly useful in finding the costs associated with different modes of transportation.

Rapid Transit

Mel has been thinking about whether he should continue to drive his car to work or whether he should use his town's rapid transit (RT) system. He knows that it costs $1.25 to ride the RT, and so it would cost him $2.50 per day to take RT to and from work.

Mel found it much more difficult to find his actual costs for driving his car. At first, he thought that he could just figure his gas costs. The drive to work is 9 miles each way, his car gets 22 miles per gallon of gas, and gas costs $1.10 per gallon.

1. Mel's Daily Gasoline Costs

Use the information above to find Mel's daily gasoline costs for driving to and from work.

There are many ways to approach this problem. Use a way that seems natural for you. Explain your method to the others in your group.

Gasoline expenses aren't the only costs that Mel pays to drive his car to work.

2. Other Driving Costs

What are the costs, besides those for gasoline, of driving to work?

To keep track of Mel's costs, we'll each start a chart or table of costs (to be filled in later), such as the following:

Mel's Driving Costs

Type of cost	Cost in $\frac{\text{dollars}}{\text{day}}$
Gasoline	.90 $\frac{\text{dollar}}{\text{day}}$
Total	

After calculating these costs, Mel realized that he must account for the wear and tear, or depreciation, on his car. Depreciation refers to the car's loss in value based on the number of miles it is likely to last. He drives an older car, which he thought would probably last another 40,000 miles. He knows from looking at the classified ads in the newspaper that his car is worth about $1,000.

3. Mel's Wear-and-Tear Costs

What are Mel's costs for wear and tear on his car for each day that he commutes by car? Use dimensional analysis to guide you. You know that when he commutes by car, he drives 18 miles per day, and you know that it will cost him $1,000 to drive 40,000 miles.

Add this cost to your chart.

Mel realized that some of the wear and tear on his car results in maintenance costs. So, he looked up his expenses for the past two years and found that he spent $900 in maintenance on his car. During those two years he drove his car 30,000 miles.

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4. Mel's Maintenance Costs

Compute how much he would spend on maintenance for driving to and from work?

Add this cost to your chart.

Mel thought of one other cost associated with driving his car—his insurance costs. So he phoned his insurance agent and found that if he stopped driving his car to work, he would receive a $72 discount on his insurance premiums every year. Mel works 240 days each year.

5. Mel's Insurance Costs

How much would Mel save per day in insurance costs if he didn't drive his car to and from work?

6. Mel's Total Costs

Add this cost to your chart, and find the total cost per day for Mel to drive to work. Do you think that Mel should drive or use the RT to get to work?

Mel's driving costs are probably much lower than yours would be—they certainly are much lower than the average in the United States, according to the Federal Highway Administration.

7. Mel Compared to the Average Driver

Why would Mel's car cost less money to operate than the average car?

Exercises

6. Mel's friend Kim drives a car that gets 20 miles per gallon around town. Like Mel, she wants to find out how much she is spending to drive to and from work in order to compare her cost with the cost of riding the RT. She also uses a higher grade of gasoline than Mel and pays $1.30 per gallon for gasoline. Kim also drives 9 miles to work and 9 miles from work each day. What are Kim's daily gasoline costs for driving to and from work?
7. Kim's car has been driven 60,000 miles. She visits the library and finds a reference book that helps her to determine that the value of her car is $7,500. She can also see that if it had been driven 80,000 miles, it would be worth $5,500. How much value is Kim's car losing for every mile she drives it? What are Kim's daily costs for wear and tear to drive her car to and from work?
8. Over the past year, Kim has driven 18,000 miles, and has spent $1,200 on maintenance for her car. Use these figures to estimate how much she spends per day in maintenance to drive her car to and from work.
9. Kim works 250 days per year. She will save $80 per year on insurance premiums if she doesn't drive to work. What are Kim's daily insurance costs for driving to and from work? How much would she save in insurance per mile by not driving to and from work?
10. On a chart, tabulate Kim's costs and find the total daily cost of driving her car to and from work. Compare this cost with that of riding RT.

In Mel's town, the RT system costs $8,000 per day to operate. Any cost that isn't paid by the riders is paid by the town through a tax that is evenly distributed among the 10,000 people in the town. Mel finds out that right now, 2,000 fares ($2,500) are collected on the RT on an average day. Daily riders include Kim, who decided to take RT after finding out how much it is costing her to drive.

8. Mel's Costs, Including Taxes

What do the citizens of Mel's town pay per day in taxes to subsidize the RT system now, and what would they pay per day in taxes if Mel were to ride the RT? Add the

cost of taxes to subsidize RT to your chart of Mel's expenses to drive himself, and make a similar chart (that includes taxes) for his expenses in riding RT.

At the company picnic for the 80 employees at Mel's workplace, Mel mentions to some friends that he computed that it costs him less to drive than to take the RT. His friends say that they made the same calculation and came to the same conclusion, and so none of them takes RT. One friend, who is not known for making much sense, asks, "What if we all took RT—would it make any difference?"

9. Mel's Costs If 80 More People Ride RT

What would the cost be for Mel to ride RT (including taxes) if all 80 employees choose to ride RT? (None of them currently rides RT.)

10. Devise a Plan

Using what you've learned from this calculation, devise a plan to lower the cost of riding RT for Mel and for others to an amount below the current cost of driving, i.e., $2.74. For simplicity, suppose that all of the people in town who don't currently ride RT have the same expense as Mel in driving to and from work.

Mel decided to get as many people as possible to ride the RT. He explained to some friends what he learned from his analysis of the costs, and they spoke with other friends, and soon there was a large but informal campaign in Mel's town to get more people to ride the RT. One year later, there were 1,300 more people riding RT to and from work each day.

11. Mel Rethinks His Decision

Now what are the costs for riding RT to work, and what are the costs for driving? Should Mel ride RT or should he drive?

Vanpools

Sylvia is an employer with a business downtown who is thinking about vanpools for her employees. She pays for each parking place occupied by her employees in the nearby parking garage. The parking garage sends her the bill, and she pays it out of a fund that she creates each year for parking and employee profit sharing. This means that at the end of the year, any money that is left in the fund is distributed among the employees. So even though some of the employees don't realize it, all employees are paying equally for the parking, even if they don't use the parking garage.

She can purchase a van for $26,000 that will seat seven and that will have a useful life of approximately 12 years. She estimates that the cost of gas, insurance, and maintenance over the 12 years is another $22,000. Sylvia estimates that on the average, a van will carry five riders.

1. Vanpool Costs

How much does the van cost per year? Use dimensional analysis to guide you through the calculation. What is the daily cost, if we assume that there are 240 workdays in a year? What is the cost for each rider?

As we learned from the calculation of Kim's driving costs, the average driver at Sylvia's company probably spends much more than $3.30 per day to drive his or her own car to work—$4.49 per day was Kim's cost. As we'll see, even if it appears that it costs you less to drive your own car, there might be a way to save money by vanpooling. So, suppose that you are one of the 400 employees of Sylvia's company, and suppose that you calculate your costs for driving to work to be $3.00 per day. Sylvia has sent out a memo asking people to sign up to join a vanpool so that she will know how many vans to buy.

You decided to add up your costs for driving and found that in addition to the $3 per day, you also pay indirectly for the parking garage fees, which now total an additional $4 per day.

2. Your Vanpool Costs

How much would it cost you daily if you joined a vanpool and if there were only one vanpool?

You decide to join a vanpool and try to convince others to join vanpools.

3. How Many Vanpools?

How many vanpools would there have to be to keep your cost for vanpooling (including the parking fees) below that of your *current* cost for driving to work (including the parking fees)?

Suppose that you are successful in convincing this many people to join vanpools.

4. Now Compare Costs

Now, how much does it cost you if you are a member of a vanpool and how much would it cost you if you aren't one of the vanpoolers?

5. Rethink Your Decision

Now which decision would you make—drive yourself or join a vanpool? Why would you make that decision? What would the effect be on your costs if each of Sylvia's employees made the same decision as you?

6. Other Ideas for Sylvia

How might Sylvia change the way she charges for vanpooling, or for parking, that would not cost her any money yet would further encourage people to use vanpools?

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